2 of 3

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# THE USE OF CUING IN TRAINING TASKS

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# The Use of Cuing in Training Tasks

## ABSTRACT

In this study five different methods of training for a simple auditory detection task were compared. The methods all represent different means of providing the trainee monitor with supplementary information about the input signals and/or the adequacy of his responses.

The first method, called cuing, proved superior. The third method, knowledge of results, although the paradigm for motor response learning, was less effective in this perceptual task. In general it would appear the trainee needs extra information about the signal rather than about his response as such.

Differences in training method show up particularly in the rate at which commissive errors, false positive responses, are made. Some tentative conclusions are drawn on the nature of perceptual learning and the vigilance decrement suggesting further research which could lead to improved training for detection tasks.

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# FOREWORD

## Purpose

Modern training methods are rooted in approaches developed by the research and findings of learning theorists. Improving performance on information processing, particularly in the area of the monitoring of perceptual tasks, involves the sifting and synthesis of human factors with laws of learning. The problem of signal discrimination appears beset by unique complexities, emphasizing the need for more effective training in areas of sensing and communication systems. The present method generally exposes the trainee to a signal and provides him with information as to its characteristics after he has had an opportunity to respond, overtly or otherwise. This knowledge of results approach is the classical means for providing feedback as a vehicle for stimulating learning, but recent investigations have indicated that under certain conditions perceptual learning may respond more effectively to cuing or guidance. The present research has been undertaken to study the relative influence of these approaches on the learning of signal detection and to analyze whatever findings emerge in terms of their implications for training operational personnel.

## Results

In the critical experiment subjects were trained to identify an auditory signal under five different conditions: Group I was trained by a yellow light flash just preceding the signal (full cuing). Group II received a blue light flash after each signal regardless of response (retrospective cuing). Group III received information as to correctness immediately after each response (contingent KR). Group IV had the first signal cued, and thereafter any signal after a missed signal was cued (partial feedback cuing). Group V combined the conditions for Groups III and IV (partial feedback cuing and contingent KR). In general, Groups I, II, and V showed significant improvement as the result of training, whereas Groups III and IV failed to better their responses. Of significance is the finding that the cued subjects, while increasing correct detections also decreased the number of false responses (commissive errors). On the other hand those trained with KR increased both correct and false responses. On the basis of this exploratory experimentation, it appears that cuing techniques may prove valuable in training for tasks requiring perceptual discriminations.

## Implications

The development of training approaches in the areas of detection and countermeasures has been concerned primarily with the stimulus, its level of simulation and method of presentation. This study has attacked the problem in terms of the human as an information processor, concentrating on what conditions of feedback provide the most effective means for enhancing learning. This could lead to better training, in less time and for less cost, for sonar and radar operators as well as those

engaged in countermeasures and the vast field of monitoring. This initial effort has already provided insights in vigilance decrement and has pointed out potentially valuable areas for further exploration.

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# TABLE OF CONTENTS

LIST OF TABLES

# INTRODUCTION

"Knowledge of results is knowledge which an individual or group receives relating to the outcome of a response or group of responses." This definition was given by Annett (1961). Essentially the knowledge comes after the response to which it relates since it is an outcome. The information can only be used in controlling or producing a subsequent response. By contrast, cuing can be defined as the provision of stimulus information before or during a response such that the response is made more effective or more likely to occur than would be the case without such information. As a simple illustration, if a subject detects or fails to detect a signal and is informed some time (even a very short time) later, this information is knowledge of results. If, on the other hand, he is told some time before the signal arrives that it will come at some indicated time and place and his response is partly or wholly determined by this information, this information is a cue. Despite the variety of tasks and the variety of ways in which KR or cues can be given there is some point in defining and juxtaposing these two techniques. Both are commonly used by instructors yet only the former has much theoretical support. The Law of Effect proclaims the effectiveness of knowledge of results as a training technique putting the major burden of the learning process on events occurring after a response. Techniques of cuing, sometimes referred to as "guidance" or as "action feedback" do not have a well-developed rationale and, in so far as they have been investigated at all, seem to be less effective. Miller (1953) and Annett (1961) give detailed discussions of the problems and summaries of the literature.

The term "cuing" and the techniques associated with it have come back into use recently in connection with teaching machines and programmed instruction. Whilst the emphasis in Skinner's system has always been on providing knowledge of results, teaching programmes make liberal use of cuing techniques to ensure that the correct response is made and so can be reinforced. Cuing is treated pragmatically whilst knowledge of results (or reinforcement) is given pride of place in the theory. Cuing techniques, demonstrably necessary in programmed instruction and used, despite the eccentricities of learning theory, by practising teachers, clearly need proper examination. Such techniques are of concern to the designers of training devices since provision for cuing or KR may be built into a device. This can have the great advantage of standardising known best methods of instruction and so simplify the task of the instructor as well as the trainee. Information on the relative merits of these training techniques can have a direct effect on the design of training devices.

## Some Experiments on Cuing

The present study is an attempt to provide some basic data on cuing as a training technique for monitoring tasks, and springs from some earlier observations by one of the authors (Annett, 1959) in which cuing was found to be effective, sometimes more effective than KR in training for perceptual tasks.

These observations will be briefly described since they are not available in published form.

The first experiment was to train the subject to report accurately the number of dots scattered over a white field illuminated tachistoscopically. Up to 50 dots were exposed and accuracy of reporting was measured, before and after training lasting one hour. During training one group was required to guess the number of dots and was then told the actual number. This procedure was taken to be a form of knowledge of results. The cued training group was simply told how many dots would be shown just before each presentation and were not required to guess. For both these groups test trials, with no information given, were alternated with training trials. The third, a control group was simply tested for the same number of trials without information. Briefly, and perhaps not surprisingly, both cuing and KR groups improved about equally in reduction of both constant error and variable error.

In a second experiment the subject's task was to detect gaps in Landolt C's shown tachistoscopically. The gaps were graded large to small plus one complete circle and gaps could be either at 3 o'clock or at 9 o'clock. Subjects simply had to report, "left," "right" or "no gap." A KR group was told right or wrong after each guess and another group given only a summary score after each set of 20 guesses. A "simultaneous cuing" group was shown all right hand gaps against a red background and all left hand gaps against a green background and was informed of this colour coding. A fourth group was shown larger than normal gaps and a control group practised with standard Landolt C's without cuing or KR. The simultaneous cuing group improved more than the other groups. Comparison of the third and fourth groups is of interest since in both cases the task was made less difficult for the training sessions. The cuing technique, however, left the essential stimulus dimension (size of gap) unchanged and reduced difficulty by providing auxiliary information. It is worth noting that in some of the earlier work on "guidance" relevant aspects of the task were changed rather than modified by additional information. For example, blocking off blind alleys in the maze alters just that aspect of the task which the animal needs to learn about.

This point is also a feature of the third experiment of which the present work is a continuation. This was an auditory monitoring task in which the subject had to detect near threshold pips (1000 cps tone lasting 50 msec.) against a background of white noise. By manipulating signal intensity pretraining performance was set at near chance level for correct detections. In test and training trials signals were randomised with respect to time. One group was then trained on KR consisting of a light flash 1.5 second after each signal which indicated a correct detection or a missed signal, depending on whether the subject had responded, and no flash after a response indicated a false positive. This condition then gave full KR. A second group was given KR in the form of a summary score at the end of each 5 minute training session. A third group received a light flash half a second before the onset of each signal on the training trials. This cue was 100% reliable and there were no catch trials but only a subsequent uncued test trial. A fourth group had neither cues nor KR but on the

training trials the noise level was reduced such that a high proportion of the signals was detected. A fifth group received no special training. The experiment was conducted in nine five minute sessions with short rest pauses between. For the first six sessions test and training trials alternated concluding with three test trials. The cuing group showed the greatest improvement. The remaining groups did not differ significantly from the control group on the final test trials.

In these studies there is a definite indication that (a) cuing is a feasible technique for training in tasks of a perceptual nature including monitoring tasks and that (b) knowledge of results, as traditionally conceived, is not necessarily the only or the best training technique. Further comparative investigations of cuing and KR should throw some light on the operative mechanism of perceptual learning as well as being of value in designing training programmes and equipment. We now turn to a review of this area.

TRAINING FOR MONITORING TASKS

Whilst monitoring tasks have been studied fairly intensively during the last decade very little is known about how to train for these tasks. Most work has centered on task and environmental variables as they affect performance and especially the performance decrement which develops during the course of a watch.

Monitoring tasks present two problems, firstly the learning of the characteristics of the signals to be detected and secondly, developing, if this is possible, resistance to vigilance decrement. In military monitoring tasks as, for example Sonar, a variety of undersea sounds, many of which are unlike surface airborne sounds, must be recognised and a high detection rate maintained throughout the watch period, sometimes under conditions of understimulation and boredom and sometimes under conditions of distraction and stress.

The literature on perceptual learning, mostly with relatively simple stimuli has been reviewed by Gibson (1953). She considers the question of whether perceptual learning should be considered as a distinct type of learning requiring its own formulation and not necessarily analogous to the acquisition of motor skills. Four main types of hypothesis are considered. Some results might be partly or even wholly explained in terms of habituation to the experimental conditions or the acquisition of what might be called task set. In this area it is more than likely that factors such as response dependencies and perseveration can give rise to spurious training increments unless the experiment is carefully controlled. Secondly, and closely related to the first, is the suggestion that the acquisition of attention and scanning habits can improve performance in a perceptual task. This appears to be the case in interpreting tachistoscopic displays and it could also occur in monitoring tasks, particularly in the visual modality where the subject is not perfectly "coupled" to the display and has more freedom in what he attends to than may be the case with an auditory task.

Gibson's third hypothesis is that in many cases sheer frequency of exposure to the stimulus can bring about important changes in perception without any deliberate differential reinforcement being supplied by the experimenter or trainer. In the first two cases differential reinforcement could play a part, even the major part in training what has been called observing behaviour. This would bring about changes in performance but would not imply any change in the percept. The evidence reviewed by Gibson does, however, suggest that changes of the percept or of perception can and do occur as a result of repeated experience and that these changes are not necessarily related to reinforcement.

Fourthly, in many experiments a case could be made for identification learning. The subject acquires the correct associative links between stimuli and responses, or, in plain language he learns what to call the things he sees or hears. Here a straightforward reinforcement model would apply. A further factor which might operate in

addition was first suggested by James. Stimuli given the same names tend to be perceived as more like and hence as more different from other 'nearby' stimuli. In this way, differential thresholds could be reduced as a result of improved absolute thresholds.

It is not necessary to go into detailed discussion of the evidence here; the interested reader is referred to Gibson. The point to be made is simply that there is some doubt about the adequacy of a straightforward reinforcement model to cover perceptual learning. Knowledge of results is the training technique appropriate to the reinforcement model and in so far as there is doubt about the appropriate model, there is doubt about the most desirable training technique.

If all, or even a part, of the improvement in performance on perceptual tasks could be accounted for on the basis of either of the first two hypotheses, cuing could be an appropriate technique. In the case of the third hypothesis, that the sheer frequency of exposure to the relevant stimulus has an effect, then cuing, by ensuring that the relevant stimulus is perceived, will increase this frequency, perhaps more effectively than could knowledge of results. As to the second type of improvement, that is to say the maintenance of a continuing level of performance in the vigilance situation, we turn now to theories of vigilance for hypotheses about possible training effects.

Theories of vigilance have been summarised by Bergum and Klein (1961) and by Frankman and Adams (1962). Extended discussion is to be found in Broadbent (1958) and Buckner and McGrath (1963). Mackworth (1950) using a classical conditioning paradigm attributes the vigilance decrement to inhibition. Factors such as rest pauses and interruptions, for instance, a message from the experimenter, temporarily remove the decrement and this could be an example of disinhibition. Although this is a learning paradigm the analogy is used to explain performance rather than the initial learning of the task. If it is to be assumed that performance depends on the characteristics of classical conditioning then logically it must be shown that the behaviour was originally acquired in this way. In the present task the signal to be detected would be the CS, the cue the UCS, and CR the key pressing response. Optimal training should result from a sequence of events in that order plus some reinforcement associated with the response but no one seriously suggests the skill is or can only be acquired in this way. It is generally agreed (see Frankman and Adams) that Mackworth's original formulation draws rather a weak analogy between watchkeeping and conditioning and we shall not, therefore, consider it from the training point of view.

Broadbent's attention model (Broadbent, 1953) is another theory which appears to cover the essential facts in a rather gross way. It is, in fact, rather imprecise. The decrement is explained in terms of sheer lack of variety in the relevant stimuli. Three types of stimuli tend to capture the attention mechanism or channel, novel stimuli, intense stimuli and stimuli of high biological importance. Since the vigilance task, by its very nature, tends to exclude novelty and often intensity as well, the only possibility is to attach biological

importance to the signals to be detected. This could only imply that detection or failure of detection should be accompanied by some biologically significant event such as a considerable reward or severe punishment. However, it is not clear that biological significance could be acquired. Broadbent appears to have in mind that the stimuli themselves should be significant, something like an innate releaser. If it is possible to draw training implications from the theory it would be essential to attach a considerable payoff to the detection of signals. In his later formulation (Broadbent, 1958) both arousal and expectancy, which we consider next, play a part.

Expectancy theory, originally proposed by Deese (1955) and elaborated most recently by Baker (1963) emphasises the subject's actual perception of features of the task such as the character of the signal, mean signal rate and inter-signal interval, and probably also the distribution of inter-signal intervals. Other factors, such as arousal, may affect performance but over and above this subjects who possess the most accurate model of the statistical structure of the task would optimally distribute their expectancies and thus perform better. This type of theory, like all the others, is not overly precise but conforms quite well to such obvious properties as that performance is worse for lower signal rates. It is not quite clear how a progressive decrement can be explained although the suggestion might be made that in so far as any missed signal will increase the effective rather than the real inter-signal interval, expectancy would be continuously adjusted to longer and longer inter-signal intervals. The theory does not handle the effects of rest pauses or interruptions by the experimenter. There is no obvious reason why such events should affect expectancy as such although they clearly do affect vigilance. It may be, as Deese originally suggested, that expectancy is only one factor in a complex situation and that arousal also is involved. However, in so far as expectancy may be a factor, training implications can be derived. The training procedure which gives the subject the most accurate information about the statistical structure of the stimulus pattern will be the most effective. Baker (1959) has shown that knowledge of results which informs the subject of correct and false detections and missed signals eliminates the performance decrement. Furthermore Baker (1958) predicts that the effect, because it is providing useful information and not just affecting motivation or arousal, will be persistent and outlast the provision of KR.

In the present case it could be predicted that cuing will be just as effective as Baker's "Full KR" treatment, more effective than simply right/wrong KR without missed signal information and that the effect will persist, that is show a resistance to decrement in test trials when no cuing is present.

Arousal theory suggests that vigilance effects are solely or principally due to the depression of level of arousal which occurs as a result of sensory deprivation. It is not necessary to examine this type of theory in detail to reach conclusions that no training implications could be derived from it. The only 'cure' is to increase stimulation on

the actual tasks. It should, however, be recognised that depression of arousal level per se is very likely a contributory cause of vigilance decrement even if it is not adequate in itself as a complete explanation. This has the implication that only a part of vigilance performance can be affected by training procedures and the results of manipulating training variables may be blurred or even obscured by it.

Holland (1958) brings rather a different approach to the problem of vigilance. He suggests that a detection is the result of an observing response and that the rate at which observing responses are made can be manipulated by the techniques of operant conditioning. The actual detection of the signal is a reinforcer and the vigilance decrement is due to the extinction of observing responses through non-reinforcement.

Of the two types of training technique in which we are interested KR should be more effective on the basis of this hypothesis. In Holland's analysis the detection of the signal itself acts as a reinforcer but an additional signal for correct detections, especially when there is some doubt on the part of the observer, should not go amiss. An error signal, if it occurs at all frequently, should tend to extinguish observing behaviour and it should in particular extinguish responses to signals about which the subject is not sure.

Assuming detection per se is reinforcing, cuing should come within the ambit of this approach. The cue would initiate an observing response which would then on most occasions be reinforced by the detection of the signal. However, only observing as a response to the cue would be so reinforced and observing in the absence of a cue would not be strengthened and would tend to extinguish. If less than 100% of signals were cued, such that uncued observing responses were sometimes rewarded by a detection, transfer would be superior. It is not, on the whole, easy to make predictions on the basis of the Skinnerian approach since what events would be reinforcing need not be specified and in the present case, though not in Holland's experiments, the response being reinforced is not easy to specify. The approach often depends on post hoc explanation or avoids explaining things altogether. If learning has occurred then reinforcement must, by definition, have taken place. Such a position, of course, leaves the reinforcement concept with no explanatory value. Only in cases when empirical results from highly similar situations are available will the true Skinnerian risk a prediction. However, in this case the Skinnerian position would probably suggest that cuing would not be effective.

In summary, the two aspects of monitoring tasks, learning the nature of the signal to be detected and the maintenance of performance (or resistance to vigilance decrement) have been considered. It is not at all easy to draw clear training implications from existing ideas about perceptual learning or from theories of vigilance. The whole area is underdeveloped when compared with motor response learning and a new approach may be required. In relation to cuing and KR, problems which arise, say, in tracking training, may appear different in the present context.

In perceptual learning part of the changes in performance may well be due to response learning but it does seem to be the case that sheer exposure to the relevant stimulation can result in changes, presumably changes in the percept or stored representation of the signal, which result finally in observed changes in behaviour to the present stimulus.

Theories of vigilance are in a similar underdeveloped state although work in this area is increasing.

On some of the theories no precise training implications can be derived but expectancy theory suggests essentially that accurate perception of the stimulus pattern results in the best performance. We may thus infer that a training technique which best enables the subject to perceive signals and to get an appreciation of their distribution will be the most effective. At the same time it must be recognised that possibly only part of the vigilance performance is subject to manipulation by training.

As regards our two principal training methods, what little can be deduced from perceptual learning theory and from vigilance theory suggests that training must be arranged such that the student gets the maximum exposure to the relevant stimulus aspects of the task. Knowledge of results on the reinforcement paradigm is only effective in so far as it provides the student with the relevant information. The cuing technique seems to be the simplest way of providing this sort of training.

## A PILOT EXPERIMENT

The purpose of the pilot experiment was principally to check the earlier findings with new equipment in preparation for more detailed investigation.

### Apparatus

The task for the subject is to detect a weak auditory signal (1000 cps. lasting 50 ms.) occurring at random intervals in a background of continuous white noise at approximately 50 db. The subject sits in a sound insulated room wearing padded earphones through which both signals and background noise are delivered. He responds to a signal by pressing a Morse key on the table in front of him. A visual display consisting of four coloured lights is always present but the lights are only used in training sessions; their functions are as follows.

(i) A yellow light, which could be flashed half a second before each signal called the cue light.

(ii) A green light which could be operated by the subject's response key if pressed within two seconds following a signal. This was the correct response light.

(iii) A red light, again operated by the subject's response key when pressed at any other time than the correct response period of two seconds after a signal. This was the incorrect response light.

(iv) A blue light which could be made to flash automatically at the end of the two seconds following a signal if no response had been made. This was the missed signal light.

The signals were generated by a highly stable oscillator gated electronically. The sequence of events was determined by a 300 foot length of film punched with holes at intervals determined by random number tables. The film was passed by a constant speed motor between two contacts. The pulse thus generated actuated a set of CR timing circuits to produce the following events at an average rate of four per minute.

1. (a) An electronic counter operates once.

   (b) The yellow cue light is switched on for sixty msec.

2. Delay of 0.5 seconds.

3. (a) The oscillator is switched in to the subject's earphones for fifty msec.

   (b) The subject's key is switched in circuit with a second (correct response) counter.

   (c) The green light is switched in circuit with the subject's response key.

4. Delay of two seconds.

5. (a) Subject's response key switched from the second (correct response) counter to a third (incorrect response) counter.

(b) The green light circuit is broken and the red light circuit connected through the subject's response key.

(c) Blue light flash lasting sixty msec. if no response has been made during the past two seconds.

Events 1b, 3c, 5b, and 5c, that is to say all the lights, could be switched in or out by the experimenter, who also controlled the synchronous motor and another light used to signal the commencement and end of a watch period to the subject.

White noise was supplied continuously to the subject's earphones during watch periods by a white noise generator at approximately 50 db. above threshold. Signal intensity could be varied in $\frac{1}{2}$ db. steps by two step attenuators. All equipment was run off stabilised power supplies and was checked regularly for stability. All equipment and the experimenter's station (with the exception, naturally, of the subject's display and response key) were outside the sound insulated room.

Experimental Plan

For the first experiment two training conditions were to be compared; (1) cuing, in which the yellow light only was used during training trials and (2) full knowledge of results in which the correct response produced a flash of the green light, an incorrect response the red light and signals not responded to after two seconds the blue light. These conditions were known as the 100% cuing condition and the KR condition.

It was suspected that cuing might be relatively more effective than KR when subjects were attempting a difficult rather than an easy task, that is to say when the probability of a correct response is low. It was therefore necessary to have subjects starting at different levels. The dilemma here was to get a reliable measure of the subject's performance without providing too much incidental practise in the process. In the first experiment this was done during an initial five minute period by the experimenter watching the response counters and manipulating the signal attenuators in an attempt to home onto the desired performance level.

The experimental schedule for both conditions was as follows:-

1. General instructions. Five minute adjustment period with signal intensity varied. 30 second break.

2. Five minute training session with cuing or KR.

3. Five minute session without training. 30 second break.

4. Five minute training session. 30 second break.

5. Five minute session without training. 30 second break.

6. )
   )
7. ) As 2 and 4 above.
   )
8. )

The numbers 1 through 8 are referred to in the section on results.

Subjects and Conditions

Fifteen subjects were trained under the cuing condition and fourteen under KR for the first day's experimental session. Of these twenty-nine sixteen returned for three more sessions on successive days, nine under cuing training and seven under KR training. More subjects had been tested but due to occasional breakdowns (or even any suspicion of unreliability in the apparatus), some results were scrapped.

The subjects were male and female members of the University of Sheffield mostly within the age range 18-24. They were paid five shillings per session lasting about an hour. Those who came for four sessions attended at the same time on each day.

The subjects were instructed as follows:-

"The task is to detect small pips which occur at random intervals in the white noise coming through the earphones. Press the key whenever you think you hear a pip. The pips will be difficult to hear and sometimes you will miss them. Also you may sometimes think you hear a pip when it is not really there. Thus there are two kinds of error you can make. Please regard these kinds of error as of equal weight, i.e. it is as important not to miss a signal as it is not to press the key when no pip is present. The experiment will be conducted in five minute sessions with a short break between each session when you may remove your earphones and rest. There will be a total of twenty pips in each five minute session. For the first five minutes the intensity of the pip will vary; after this it will remain constant for the remainder of the experiment."

The function of the cuing or KR lights (whichever was appropriate) was explained after he first adjustment period. Subjects were assured that all the lights were 100% dependable. In the cuing condition they were instructed to press the key only on actually hearing the signal and it was explained that the function of the cue was to help them to hear it.

Any queries during subsequent rest pauses were answered non-committally. During these pauses the experimenter briefly showed himself at the door and told the subject he could relax.

Pilot Experiment: Results

Fifteen subjects completed a one-hour training period under the cuing condition and fourteen subjects under the KR condition. Of these nine in the cuing group and seven in the KR group returned for three further daily training periods. Results for the first day only (29 subjects) are presented separately but include the day 1 results of the 16 subjects who continued for a total of four days.

A percent correct (% C) and a percent error (% E) score was calculated for each subject for the relevant test sessions as follows:-

$$\% C = \frac{\text{signals detected}}{\text{signals presented}} \times 100$$

$$\% E = \frac{\text{false positive responses}}{\text{total responses}} \times 100$$

Table I shows the results obtained on the first day of training for 29 subjects for session 3 (the first non-training session) and sessions 7 and 8 combined (the last two non-training sessions). Individual scores are shown in appendices A.1.(i) and A.1.(ii).

Table I

Mean % C and mean % E scores for third and last two sessions of day 1.

| Condition | N | Session 3 | | Sessions 7 and 8 | |
|---|---|---|---|---|---|
| | | % C | % E | % C | % E |
| Cuing | 15 | 48.73 | 19.80 | 48.87 | 21.80 |
| KR | 14 | 61.86 | 28.79 | 65.00 | 32.71 |

There are two obvious differences between the two training conditions which appear to be little affected by practice. (a) The KR group make consistently more correct detections, and (b) the cuing group has a consistently lower proportion of false positive responses.

Table II shows the results of the 16 subjects who continued for 4 days, the scores being those obtained at the end of each daily training period (sessions 7 and 8 combined). Individual scores are shown in appendices A.2.(i) and A.2.(ii).

Table II

Mean % C and mean % E scores for the last two sessions on days 1 to 4.

| Training Condition | No. of Ss | Day 1 | | Day 2 | | Day 3 | | Day 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | % C | % E | % C | % E | % C | % E | % C | % E |
| Cuing | 9 | 42.90 | 25.33 | 50.00 | 22.56 | 46.11 | 21.67 | 46.11 | 16.00 |
| K.R. | 7 | 64.71 | 31.71 | 62.29 | 30.29 | 65.00 | 27.14 | 67.14 | 27.43 |

The same difference between the groups in distribution of correct and incorrect responses is found. Slight increases in detections are noted for both groups and false positive responses are slightly reduced the reduction being greater for the cuing group.

An initial aim was to test the hypothesis that cuing would be more effective in an initially more difficult task. It had been hoped to assign subjects to different difficulty levels by a short pretraining procedure but in this we were quite unsuccessful. As the data in the appendices show attempts to spread out the initial detection scores failed, especially in the KR group, and hence no conclusion about a possible interaction between training method and initial difficulty level can be drawn.

Discussion of Pilot Experiment

The training effect of both conditions is rather small. In the pilot experiment there may be several contributory reasons. After the initial setting of difficulty level a five minute training period intervenes before performance is measured in the test condition. At this stage the two groups are already markedly different and there is no way of telling whether they were poorly matched or whether the difference is due to the first five minutes training. Since overall gains are small, attributing differences to the initial five minute period would imply that most of the learning occurs during this period.

A further possibility is that a vigilance decrement which neutralises a training effect develops during the training period. Despite rest pauses at five minute intervals such a decrement might reasonably be expected in this type of task. The subjects were isolated from the experimenter and from the rest of the normal environment. Test performance on the first test session of the four days does show an upward trend lending some support to this hypothesis. The problem of setting difficulty level was more serious than had been anticipated. The adjustment procedure had to be kept as short as possible to minimise unwanted training effects so the setting was made on a small amount of data and one might expect that it would be unreliable. There may, however, have been another effect. Recent work by Colqhoun of the MRC APRU Cambridge (private communication) suggests

that the first few signals in a watch may determine performance for the rest of the watch. Colqhoun has evidence to suggest that the time of occurrence of the first signal, whether it is detected or not, has a marked effect on the vigilance decrement. Thus in the present case random differences in the time at which the first signal is given will be a major determinant of performance which will serve to blur underlying differences in sensitivity to signals. The data from this experiment are inadequate to test any hypothesis about an interaction between training method and initial difficulty level.

Despite the general inconclusiveness of the experiment the cuing condition did not show up too badly. There is no suggestion that cue dependence is a factor of any significance in the present case. Although in the cuing group detections were fewer so also were false positive responses. The most interesting and unexpected result was the marked difference in style of performance between the two groups.

## EXPERIMENT II

### Introduction

The pilot experiment was disappointing in so far as little training effect was found in either group. It seemed likely that some training benefit might be concealed by vigilance decrement since the test trials were, naturally, at the end of the training session when decrement would have reached a maximum. In the second and main experiment steps were taken to minimise this effect by (i) increasing the signal rate from 20 to 30 signals per five minute period, (ii) by providing a ten minute rest pause between the end of training and the beginning of the testing session, and (iii) by ensuring that a signal would in all cases occur very shortly after the beginning of each five minute session. The increased signal rate also increases the available data and has an additional payoff in terms of the probable reliability of the performance measures.

The method of setting the difficulty level, requiring some skill on the part of the experimenter, was established as a result of experience on the pilot experiment. This was done during the first five minutes of the experiment as follows. Five signals were given at a clearly audible level. The signal strength was then attenuated by 3 db and a further three signals were given followed by a 2 db attenuation and another three signals. By this stage many subjects failed to respond to one or more of the signals and the signal was then attenuated in 1 or ½ db steps until the required difficulty level was reached. This procedure permitted a rough grading of the subjects but not for precise matching.

The difference between cuing and KR in style of performance was unexpected but shortly afterwards a similar finding in the visual modality came to our notice (Wiener, 1962). This finding is important to vigilance training since it may or may not (depending on the circumstances) be desirable to train subjects to make commissive errors. For a closer examination of this phenomenon the KR condition, green light for correct responses, red for false positives and blue for missed signals, was split into two sub-groups, one with red and green light only, and one with the blue light only following each signal, missed or not. The theoretical significance of this distinction is as follows. The new red and green light condition gives the subject knowledge of results conditional on positive performance. If he does nothing he gets no information. The new blue light condition gives full knowledge of results whether or not the subject does anything. If he makes a detection this is confirmed. If he misses a signal he is informed in two seconds by the light, and if he makes a false positive response no blue light appears and his guess is disconfirmed.

The red and green light condition conforms to the reinforcement paradigm; the green light should reinforce correct responses and the red light should extinguish incorrect responses. From the point of view of cognitive theories the fact that feedback information is contingent on the subject's response is of no special importance.

Learning occurs by virtue of the acquisition of relevant information. It is true that relevant information can be acquired by making a response and observing the consequences but this can be inefficient. In this case relevant information for the trainee is, presumably, information about the signal, which can be acquired by attending to the signal, and about its distribution over the watch period. Under the "blue light only" condition, subjects get full information about the distribution of signals which they could only get in the KR condition by a high level of actual detections and also by making a large number of commissive errors. The blue light condition could be construed as retrospective cuing or as a type of non-contingent knowledge of results (i.e. not dependent on a subject's responses). This condition is, however, distinct from the standard cuing condition (a yellow light just before each signal during the training trials) in so far as it cannot support responses, that is act as a crutch. The yellow light condition (standard full cuing) by giving a reliable warning indicates to the subject precisely when he must listen carefully and when he can expect a signal, such that a high proportion of signals are actually heard.

Reinforcement theorists might be tempted to suggest that in the cuing condition self reinforcement can occur by some covert process. But once the concept of reinforcement moves out of the realm of observables its explanatory value is greatly impaired.

On the hypothesis that the role of the additional signals (both cues and KR) in this task is to provide the subject with information relevant to the discrimination of the signal and its distribution over the watch period, the conditions should fall into the rank order of effectiveness, (1) cuing by the yellow light, (2) retrospective cuing or non-contingent KR by the blue light and (3) KR (or reinforcement) by means of the red and green lights.

To these three a further two conditions were added: (4) partial feedback cuing and (5) partial feedback cuing plus KR (reinforcement). (Condition 5 was a straightforward combination of conditions 3 and 4.) Whereas the blue light condition could be termed "non-contingent KR" the partial feedback cuing condition might be termed "contingent cuing." Under this condition the subject is cued only when he fails to detect a signal and the cue is withheld when signals are correctly detected. The purpose of 4 and 5 was largely exploratory. Given that cuing is an effective training technique we must be prepared to do something about cue dependence should it arise. Many previous studies of cuing in other types of tasks suggest that cue dependence is the main limiting disadvantage of the technique. In most instances cues have been withdrawn abruptly yet one might guess that gradual withdrawal of cues would overcome, at least in part, the problem of cue dependence. The successful use of cuing as a training technique might well rest on the method of withdrawing cues. Rather than rely upon set schedules of cue withdrawal the possibility of linking withdrawal to some criterion of subject performance seems promising. This condition, then, was an extremely simple case of conditional cue withdrawal to explore this possibility.

The fifth condition was added after the results of partial feedback cuing were known. As can be seen below these results show no training effect at all, and it was hypothesised that this might be due to the fact that the partial cuing system used yields no knowledge of what a random distribution of signals in time is like. It may in fact result in a false conception of the kind of distribution involved. With partial cuing plus contingent KR (conditions 3 and 4 combined) the subject is intermittently reminded of the nature of the signal, by the cue, and has an opportunity to gain some knowledge of the distribution through his responses. It might be expected that such a combination of training conditions would yield results superior to either condition taken alone.

Apparatus

The equipment used was functionally the same as before with the addition of a circuit to produce the partial feedback cuing for conditions IV and V and a number of other changes to improve reliability and performance.

Subjects and Conditions

100 subjects were recruited from the same population as before and paid 5/- per hour (about 71 cents).

The general operating conditions were the same but, as previously described the signal rate was increased from an average of four per minute to an average of six per minute with one signal always occurring during the first few seconds of a watch period. This together with a ten minute break before the post test was introduced to reduce uncontrolled vigilance effects.

The training sequence for all five conditions was modified to the following schedule:

1. General instructions. Five minute adjustment period with signal intensity varied.

   30 second break.

2. Five minute pre-test session without training.

   30 second break.

3. Specific instructions for the relevant training condition.

   5 minutes training period.

   30 second break.

4. As 3 above (repeating specific instructions only if requested).

5. As 3 and 4.

   10 minute break during which S is engaged in general conversation in the sound-insulated room.

6. 5 minute test session without training.

   30 second rest pause.

7. As 6 above.

The adjustment technique used in session 1 is as follows:

The first five signals are given at a clearly audible level, this is then attenuated by 3 db and another 3 signals given followed by a 2 db attenuation and a further 3 signals. Further attenuations are made in 1 db or $\frac{1}{2}$ db steps until the required level of performance is reached. In practice it was usually, but not always, possible to determine a high or a low level of performance by this technique but precise matching of the groups was out of the question.

Subjects were instructed before the first watch period as follows:

"The task is to detect small pips which occur at random intervals in the white noise coming through the earphones. Press the key when you think you hear a pip. The object is to get as high a score as possible and to make as few false responses as possible. Your response is counted as false if you press the key when no signal is actually present. For the first five minutes the intensity of the signal will vary. At first it will be easy to hear and then gradually become more difficult. After this it will remain constant for the rest of the experiment. The experiment will be conducted in five-minute sessions with a short break between sessions when you may remove the earphones and rest. There will be a total of thirty pips occurring at random intervals in each five-minute session."

The function of the light signalling the beginning and end of sessions was then explained. After the second session the function of Cue and KR lights was explained as appropriate. Five groups of twenty subjects each were subjected to the following training in sessions 3, 4, and 5.

Group I. 100% cuing. A yellow light flash half a second before each signal.

Group II. Retrospective cuing (or non-contingent KR). Blue light flash 2 secs after each signal irrespective of S's response.

Group III. KR (contingent) correct responses followed immediately by a green light, incorrect responses followed immediately by a red light.

Group IV. Partial feedback cuing. The first signal is cued. From then on if a signal is missed the next signal is cued, if a signal is detected the next is uncued. False positives have no effect.

Group V. Partial feedback cuing and contingent KR - conditions for groups III and IV above combined.

In conditions IV and V subjects were told "the yellow light here (pointing) will flash half a second before some of the signals. Whenever the light flashes it will always be followed by a signal. Press the key if you hear the signal. At least 50% of the total signals will not be preceded by the light. The light is there to help you hear some of the signals."

Alternative measures of the efficiency of signal detection.

Our finding that there are important differences between training conditions with respect to correct detections and false positives suggests the desirability of some unified index of efficiency whereby these different patterns of performance could be compared. This question would not arise in a situation where detections were desirable irrespective of false positives or the alternative case where the lowest possible false positive rate is required. In such cases where the value of different response categories is of importance one simply chooses the training condition which best approximates the desired criterion.

The theory of signal detection (c.f. Tanner, Swets and Birdsall, 1961) provides an approach to this type of problem. Two quantities, d-prime and beta may be derived from psychophysical data which define respectively sensitivity and decision criterion. According to the theory sensitivity remains roughly constant whilst apparent differences in threshold are ascribed to changes in the criterion applied by the subject in deciding whether or not a signal has occurred. In the present experiments differences between training conditions could conceivably be due to differences in decision criteria rather than differences in true sensitivity. The calculation of d-prime and beta depends on the generation of receiver-operating-characteristic curves by requiring subjects to adopt different criteria on different occasions in the situation where a signal is or is not presented and a decision called for in a fixed short period of time. Egan, Greenberg and Schulman (1961) have attempted to extend the technique to the method of free response, that is to say when the time interval for a decision is not strictly defined as would be the case in vigilance experiments. A quantity $d_s$ representing detectability which is independent of the decision criterion used can be calculated from data generated by subjects who have been urged, at different times, to adopt a variety of criteria from strict to lax. The criterion itself cannot be directly evaluated. The calculation depends on the slope of response frequency curves at times following a signal. Such times are not available for the present data. This and other technical problems preclude the application of signal detection theory to the present data but it is also the case that

this type of analysis requires at least one assumption which could not properly be made. Signal detection theory assumes a fixed time interval during which a decision about the presence or absence of a signal is made. However as the time interval during which signals may arrive increases so the likelihood that the subject is not, at any given moment, paying attention to the task also increases. Only if we can be fairly sure that the subject is making decisions about the particular input provided can decision theory be applied. In the vigilance situation it seems probable that, for some periods at least, the subject is distracted by other inputs or may have sunk into some kind of sleep state. He may be making decisions about the pattern on the wallpaper or he may not be making decisions at all. This consideration is a bigger obstacle to the application of signal detection theory than technical problems of the form of the data.

Information theory provides a convenient neutral composite measure of efficiency based on a minimum number of assumptions. Efficiency can be described in terms of the degree to which the input message could be reconstituted from a knowledge of the subject's responses. The index $T(x;y)$, information transmitted, can be calculated from the data. The duration of a trial, 5 minutes, and the duration and frequency of the periods during which a response is accepted as correct, 30 x 2 seconds, define the probability of a response being correct. Signal dimensions did not vary during the experiment and signal occurrence was approximately equiprobable throughout the five minute session. Strictly speaking it should be assumed that the five minutes was divided into a series of two-second chunks in any of which a signal would or would not occur and a response would or would not occur. This assumption would be untenable if subjects made more than 150 responses or if they frequently made responses less than two seconds apart. Fortunately the data meet these assumptions and we may take information transmitted as a fair representation of the realities of the task and a useful approximate measure of transmitting efficiency which adequately combines correct and incorrect responses.

A numerical example may serve to make the transformation of raw data into information transmitted scores clear:-

Correct responses (out of a possible 20) = 15

Error responses (out of a possible 130) = 12

| | Total signals | Total non-signal periods | |
|---|---|---|---|
| Response | 15 | 12 | 27 |
| No Response | 5 | 118 | 123 |
| | 20 | 130 | 150 |

$$H(x) = \log 150 - \frac{1}{150}\left[20\ (\log 20) + 130\ (\log 130)\right] = .56651$$

$$H(y) = \log 150 - \frac{1}{150}\left[27\ (\log 27) + 123\ (\log 123)\right] = .68008$$

$$H(x;y) = \log 150 - \frac{1}{150}\left[15\ (\log 15) + 12\ (\log 12) + 5\ (\log 5) + 118\ (\log 118)\right] = 1.05959$$

$$T(x;y) = H(x) + H(y) - H(x;y) = .17700$$

Results of Experiment II

Table III summarises the results of 100 subjects, 20 in each of the five conditions and compares mean pre-test (session 2) with mean post-test (sessions 6 and 7) for % C and % E scores. Individual scores are given in appendices B.1.(i) to B.1.(v).

Improvement in detections is noted for all groups and is fairly large for the two cuing conditions I and II and rather small for condition IV. Thus unlike the pilot experiment the new schedule demonstrates some training effect.

A particularly interesting finding is that false positive responses are generally increased as a result of practice except in condition I, 100 cuing, where there is a slight decrease. Although group III, the KR condition, begins with a low false positive rate the effect of training is to increase this quite markedly.

Table III

Mean percent correct detections and mean percent false positive responses for twenty subjects in pre-test and post-test over five training conditions.

Pre-test = session 2.

Post-test = sessions 6 and 7.

| Training Conditions | Pre-test | | Post-test | |
|---|---|---|---|---|
| | C % | E % | C % | E % |
| I | 31.5 | 29.7 | 45.7 | 25.7 |
| II | 29.9 | 33.3 | 44.5 | 36.0 |
| III | 36.2 | 15.9 | 46.9 | 28.1 |
| IV | 29.1 | 32.3 | 33.8 | 35.4 |
| V | 35.5 | 25.8 | 47.8 | 26.8 |

Table IV shows the same data transformed into information scores taken to be an index of transmitting efficiency. Individual scores are shown in appendices B.2(i) to B.2.(v). Since the pre-test scores in table IV vary somewhat between conditions an analysis of covariance was performed and the results are summarised at the foot of table IV. Adjusted post-test means are shown in the final column of table IV.

The conditions are shown to be significantly different on post-test $F=3.047$, $p<.025$. This difference may be largely due to group IV, partial feedback cuing which, unlike the other groups shows no improvement as a result of practice.

Table IV

Mean rates of information transmitted, in bits per response.

| Training Condition | Pre-test | Post-test | Adjusted Post-test means |
|---|---|---|---|
| I | .11964 | .17516 | .17048 |
| II | .09268 | .13575 | .15102 |
| III | .14011 | .15175 | .13219 |
| IV | .09044 | .08453 | .10139 |
| V | .12430 | .16816 | .16026 |

$N = 20$ for each of the five training conditions.

Analysis of Variance yields: Pre-test $F = 1.06$ NS

Post-test $F = 2.768$ $P<.05$

Analysis of Co-Variance: $F = 3.047$ $P<.025$

Conditions 1 and 4 $p< .01$ ) two-tailed

" 2 and 4 $p< .05$ ) two-tailed

" 5 and 4 $p< .01$ ) two-tailed

" 1 and 3 $p< .05$ one-tailed

Table V shows the significance of pre-test/post-test differences. The two cuing groups I and II show significant increases in information transmitted whilst groups III (KR) and IV (partial feedback cuing) do not improve significantly. Group IV is significantly worse than groups I, II and V. The difference between I and III approaches significance at $p < .05$ on a one tailed test.

100% cuing therefore provides the most effective training but cuing contingent on performance has no effect. 100% cuing is the only condition showing a downward trend in false positive responses whilst KR results in a considerable increase in false positives.

Table V

Pre-test / Post-test differences

t values calculated from "information transmitted" scores.

| Training Conditions | t | p | |
|---|---|---|---|
| I | 2.15 | $p < .025$ | 1 tailed |
| II | 2.29 | $p < .025$ | " |
| III | 0.63 | N.S. | - |
| IV | - | No mean increase | - |
| V | 2.92 | $p < .005$ | 1 tailed |

So far the results indicate inter-group differences in achievement. There is also some evidence on the question of the effects of different training procedures on vigilance decrement. The post-test is made up of two successive five minute sessions which followed the ten minute relaxation period. Scores for the second of these two sessions were invariably lower than for the first (see Table VI) so we can infer that some vigilance decrement occurred and take the difference between the two sessions as evidence of its magnitude. We can have some confidence in this since vigilance decrement tends to be exponential, most decrement occurring near the beginning of the watch. It should also be noted that the ten minute rest period was a genuine relaxation period, whilst during the ½ minute separating the last two sessions the subject remained in the room and did not converse with the experimenter but simply removed his earphones. No prediction was made about the effectiveness of the conditions in reducing vigilance decrement but it may be noted that condition I produced only a slight reduction in detections, from a mean of 14.3 out of thirty signals to 13.2 whilst group III produced a decrement of 15.9 to 7.1, a very considerable decrement. Groups II and IV and V hold intermediary positions but group IV was in any case scoring rather low.

Table VI

Average numbers of correct detections and errors for the last two five minute sessions.

| | Detections | | Errors | |
|---|---|---|---|---|
| Training Condition | 1st | 2nd | 1st | 2nd |
| I | 14.3 | 13.2 | 4.9 | 4.6 |
| II | 14.4 | 12.3 | 9.0 | 8.0 |
| III | 15.9 | 7.1 | 7.1 | 4.1 |
| IV | 11.0 | 9.4 | 7.8 | 6.3 |
| V | 15.5 | 13.2 | 6.5 | 4.2 |

Error scores are also reduced by small amounts, the pattern being similar to that for correct responses with cuing showing the smallest

reduction and KR the greatest. From this we may infer that the decrement is brought about essentially by a reduction in rate of responding and does not necessarily indicate a loss of discrimination. However in the two groups with which we are mainly concerned, I and III, there appears to be a difference in vigilance decrement, as measured here, group I being rather resistant to decrement and group III showing a rather marked decrement.

Table VII shows the number of subjects in each group whose detection performance on the second of the last two tests is better, the same, or worse than performance on the first of these two tests. (Note that in group III the second test score for one of the subjects is missing.) The table shows the probabilities, as determined by the Binomial test (ref. Siegel, 1956) of the distribution of decrement and no decrement, that is subjects whose performance was the same or better, compared with those whose performance was worse on the second of the two final tests. Since a decrement could be predicted the probabilities refer to one tail of the distribution. For the whole group significantly more subjects get worse. In the individual groups only group III shows a significant decrement.

Table VII

Number of subjects under each condition showing a vigilance decrement between the first and second of the last two five minute sessions.

| Training Conditions | I | II | III | IV | V | Total |
|---|---|---|---|---|---|---|
| Better | 7 | 5 | 3 | 6 | 5 | 26 |
| Same | 3 | 4 | 2 | 1 | 1 | 11 |
| Worse | 10 | 11 | 14 | 13 | 14 | 62 |
| p | .588 | .412 | .032 | .132 | .058 | .02 |

Results are grouped into decrement/no decrement, (i.e. "Better" and "Same" are combined). p is, on a one-tailed binomial test, the probability of the frequency of observed numbers showing vigilance decrement.

Note: One of the two test results for one subject in group III is missing. Total N = 99.

Summary of Results

(i) The two 100% cuing groups and the partial cuing plus contingent KR group show significant increases in average information transmitted as a result of training. Knowledge of results and partial feedback cuing do not show significant increases.

(ii) As in the pilot experiment cuing and KR show marked differences in the pattern of performance. The cuing group whilst increasing correct detections reduces commissive errors whereas the KR treatment results in a marked increase in commissive errors together with an increase in correct detections.

(iii) The partial feedback cuing seems to have no training effect.

(iv) There is some evidence of a vigilance decrement, essentially a general reduction in rate of responding, during the last two sessions and this is slight for group I, cuing, and rather marked for group III, KR.

## DISCUSSION AND CONCLUSIONS

It has been demonstrated that training in a perceptual task akin to sonar and radar watchkeeping is possible, but this is only a small beginning and the limitations should be considered. Only one simple stimulus or signal was used at near threshold level. There was not, as in many monitoring tasks, a variety of different new sounds to be distinguished and identified. In many real life situations the signals would be of greater intensity. Failure to respond to a near threshold stimulus may or may not be of the same kind as failure to detect a more intense signal at the end of a long watch. The present experiment is a "miniature situation" with respect to the variety and intensity of the signals used, and both training and watchkeeping periods are shorter than would be the case in real life monitoring tasks. Within these limitations certain characteristics of learning and performance which are relevant to training have emerged.

Notable differences have been found between training methods. The most striking difference is between cuing and KR. In the pilot experiment subjects in the cuing group made consistently fewer commissive errors and in the main experiment the KR group increased these errors as a result of training whereas the cuing group showed an improvement on this count. A very similar finding has come out of a recent study by Wiener (1962) in the visual modality and it seems that this characteristic difference may have some generality. Wiener used the Jerison adaptation of the Mackworth Clock Test and, amongst other things, compared the effects of three training conditions, (1) no knowledge of results, (2) KR contingent on the subject's response (comparable to condition III in the present study) and (3) full knowledge of results where the subject is automatically informed of correct detections, false positive detections and missed signals (comparable to the KR condition in the pilot experiment of the present study). Wiener's partial KR group, receiving feedback about correct detections and false positive responses showed the same increase in false positives but his full KR group shows a decrease as a result of training. Missed-signal information seems to make the critical difference, and when we see that groups I and II in the present study showed learning without contingent feedback Wiener's results are highly consistent with the explanation which we shall put forward for the present results. The finding sheds some light on the mode of operation of KR in this type of perceptual learning task.

The fact that cuing is relatively more successful suggests that perceptual learning of this kind can be regarded as a passive "cognitive" process, more precisely that responses, overt or covert, are only important for the stimuli they produce. The extreme position, that no learning can occur without a response being made, and that consequences of the response are the only effective agent in learning is, on this view, untenable, notwithstanding the obvious fact that only a change in behaviour can stand as evidence that learning has occurred.

The comparison between cuing and KR is of interest here in so far as both techniques permit the subject to acquire information. In KR

the information is contingent on responses, in cuing it is not. The KR group can only acquire information by responding and how much information they get depends on how they respond. We assume that in this case the information the subject needs to acquire is essentially a sample of the relevant stimulus. An input will not count as a sample unless it is a confirmed or authenticated sample; that is to say, there must be sufficient information to enable the subject to classify samples into signal and non-signal. In the KR situation he has to make a response to be quite sure about this, in cuing he does not. Wiener attributed the higher rate of commissive errors in his group II to the fact that the subject would have to respond quite frequently to get anything like the same amount of information as subjects for whom missed signal information was provided automatically. Wiener concludes, quite reasonably, that this response pattern persists, that is, it is learned. However, if we take the view that in this case response learning is relatively insignificant then Wiener's suggestion is inconsistent. If we are to maintain that the effective change in behaviour is dependent on changes in discrimination we must conclude that the KR group is simply less able to tell the difference between signal and non-signal, and the response pattern is only a contingent fact. During the last two five-minute sessions the KR group begins (in the first of these) by producing responses (correct and incorrect) at a slightly higher rate than the cuing group (a mean of twenty three responses compared with 19.2) but in the second five minute session the cuing group has dropped to a mean rate of 17.8 and the KR group to a mean rate of 11.2 responses. The ratio of false responses to correct detections is consistently higher for the KR group. Thus the KR group were not simply making more mistakes through a higher output, but were showing a poorer discrimination between signal and non-signal. The comparison of average information rates shows that the higher rate of commissive errors is not simply commensurate with a higher general rate of responding. We would therefore conclude that the characteristically higher error rate of the KR group is not simply a matter of having learned to respond more frequently but is due to a lower level of discrimination.

In the introduction we considered the twofold problem of monitor training, perceptual learning and resistance to vigilance decrement.

On the first point cuing provides the maximum exposure to the signal and gives the fullest information about the distribution of the signal in the watch period. This result is most consistent with the "accumulated experience" hypothesis of perceptual learning. In our group I the cue, acting as a warning signal, permitted the subject to perceive the signal more frequently than in any other condition. It will be remembered that subjects were asked to respond to heard signals during training but no record was made of their responses since it would be impossible with 100% cuing to distinguish behaviourally between response to the cue and a genuine response to the signal. That the subjects in this condition did actually hear the signal more frequently is nevertheless quite beyond doubt. It can be demonstrated subjectively by anyone who cares to try and a reduction in threshold due to the warning signal has been demonstrated behaviourally with the necessary controls, by Howarth and Treisman (1958). These workers also

found an effect when the warning signal actually <u>followed</u> the signal to be detected, for times up to half a second. In group II of the present experiment the frequency of detection due to the retrospective warning signal is almost certainly lower since the interval is much larger. In this group as in group I, however, each signal is marked such that, in addition to confirming actual detections, full information about the distribution of signals in a watch period is provided.

The difference between groups I and II therefore is the difference due to the number of samples definitely identified as "signal." The difference is slight but is in the predicted direction. Groups I, II and III come out in the order predicted by the hypothesis that learning is proportional to exposure to authenticated samples of the signal, and signal distribution information. Group I has maximum exposure to the signal plus full information about its frequency and distribution in time. In group II fewer signal samples are availabl but full information on signal frequency and distribution is provided. In group III, probably comparable with group II on the first count, incomplete information on signal distribution is available.

Group V, with a proportion of clearly authenticated sample signals plus the opportunity of gaining some (although incomplete) information about the distribution through contingent KR, occupies an intermediate position quite consistent with the hypothesis under discussion.

The results of group IV, who did not improve at all with practice, fall into the same pattern. The partial feedback cuing arrangement meant that something less than half the signals were cued in each case. We can assume that a fairly high proportion of these were actually detected and so contributed authenticated samples of the signal. A lower proportion of uncued signals would be detected but with neither cue nor KR their authenticity would be left in doubt. It is probably fair to conclude that this group had the poorest opportunity of accumulating the relevant experience; furthermore, since many signals would be missed, a rather inadequate impression of signal distribution characteristics would be gained. Thus although no advance prediction was made about this group, the results can be seen to fit closely with those of the other groups. The partial feedback cuing, it will be recalled, was included to explore the possibility that some technique of cue withdrawal, based on student performance, would minimise transfer problems. As it turns out cue withdrawal was initiated before any learning could be established. Indeed the mechanics of cue withdrawal interfered with the very processes it was hypothesised were necessary for learning.

This is not to say that this technique, or something like it would not be appropriate after initial essential learning had taken place and be of value in preventing cue dependence. The criterion on which cues were withdrawn was based on a guess. The criterion of one correct detection was obviously inadequate especially in relation to the signal distribution. However, a suitable criterion can only be discovered empirically. It would certainly seem advisable to distinguish clearly between testing and training trials where the testing, as in this case, changes the structure of the task. Cue withdrawal under the conditions

we have used seems to prove more feasible where contingent KR is provided as well. A combination of the partial cuing with non-contingent KR might be expected to yield an even better result. We should not conclude that it is yet established that some technique of cue withdrawal is either undesirable or unattainable.

Concerning theories of vigilance some tentative conclusions can be drawn from this experiment. Whatever factors contributed to monitoring performance some at least are susceptible to training. It follows that suggested factors such as arousal and stimulus variety cannot, without additional postulates, account for monitoring performance.

Holland's approach to vigilance through the reinforcement of observing responses does not fit our results. Under cuing, only observing responses made to cued signals would be reinforced by a detection so there is no chance of strengthening observing behaviour in the absence of the cue, yet clearly subjects do learn. By contrast the KR condition should strengthen observing responses with a resulting improvement in detection. For this approach the conditions come out in the reverse of the predicted order of efficiency.

Of all the views discussed Baker's expectancy theory best fits the present data. Since on this theory detection is governed by expectancy, training which provides the most realistic set of expectations should be superior. The group which has the best opportunity of learning the nature of the signal and its distribution will perform best and be most resistant to vigilance decrement. Baker explicitly predicts that the effects of such training will effectively outlast the provision of any training aid. On this criterion groups I, II and III come out in the predicted order, group I being quite resistant to decrement and group III showing a marked and statistically significant decrement. Group IV should come out even worse on this criterion but in fact the reduction in correct detections between the first and second of the two final sessions is smaller than that for group III (although this is to some extent offset by a smaller reduction in false responses). However it should be noted that group IV is already performing at a low level and is the only group performing worse on post-test than on pre-test. With the exception of the worst performing group the extent of decrement appears to be related to training efficiency, that is to say the better the performance the greater the resistance to decrement. This finding should be regarded as somewhat tentative in view of the rather simple measure of decrement, the difference in performance between two five-minute sessions.

Concluding overall, these findings are consistent with the simple view that exposure to authenticated samples of the signal is the most effective way for a subject to learn to distinguish between signal and non-signal. To learn the statistical nature of the distribution of signals over a watch period is also an asset to performance and to maintaining that performance. Here again maximum exposure to signals such that few if any of them are missed is the most reliable way of acquiring this information. The technique of cuing satisfactorily accomplishes this form of training, and, on previous evidence, is preferable to simply making the task easier.

Much has been said about the distinction between cuing and knowledge of results (see Annett, 1961). There is little doubt that the potentiality of cuing as a training technique has been underestimated during a long period when the Law of Effect has been the principle mainstay of learning theory. The argument of this report is that, in this type of task, KR is effective only in so far as it provides the same kinds of information as can be supplied by cuing. In short the main function of both cuing and KR in this task is informative. In the present case giving KR on a reinforcement paradigm turns out to be a less effective way of providing the subject with the information he needs.

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Appendix A.1. (i)

## 100% CUING CONDITION

Percentage correct detections of total signals presented, and percentage false responses of total responses made for 3rd and last two 5 minute sessions of day 1.

| Third session | | Last two sessions | |
|---|---|---|---|
| % correct | % error | % correct | % error |
| 62 | 11 | 71 | 29 |
| 39 | 50 | 60 | 31 |
| 42 | 20 | 46 | 0 |
| 35 | 0 | 30 | 8 |
| 55 | 15 | 70 | 7 |
| 65 | 13 | 55 | 19 |
| 55 | 42 | 48 | 42 |
| 45 | 18 | 33 | 38 |
| 45 | 50 | 48 | 14 |
| 85 | 11 | 73 | 15 |
| 50 | 0 | 53 | 13 |
| 65 | 0 | 58 | 15 |
| 35 | 0 | 38 | 0 |
| 33 | 17 | 36 | 36 |
| 20 | 50 | 14 | 60 |
| Total 731 | 297 | 733 | 327 |
| Mean 48.73 | 19.80 | 48.87 | 21.80 |

Appendix A.1. (ii)

## K. R. CONDITION

Percentage correct detections of total signals presented, and percentage false responses of total responses made for third and last two 5 minute sessions of day 1.

| | Third session | | Last two sessions | |
|---|---|---|---|---|
| | % correct | % error | % correct | % error |
| | 65 | 27 | 72 | 36 |
| | 70 | 48 | 61 | 17 |
| | 88 | 25 | 68 | 46 |
| | 25 | 17 | 63 | 14 |
| | 60 | 50 | 70 | 47 |
| | 80 | 24 | 63 | 24 |
| | 65 | 7 | 68 | 21 |
| | 65 | 13 | 45 | 14 |
| | 65 | 46 | 70 | 35 |
| | 60 | 8 | 55 | 27 |
| | 75 | 0 | 63 | 39 |
| | 75 | 21 | 68 | 36 |
| | 53 | 50 | 75 | 56 |
| | 20 | 67 | 69 | 46 |
| Total | 266 | 403 | 910 | 458 |
| Mean | 61.86 | 28.79 | 65.00 | 32.71 |

Appendix A.2. (i)

## CUING CONDITIONS

Percentage correct detections of total signals presented and percentage false responses of total responses made for the last two 5 minute sessions on four consecutive days.

| | Day 1 | | Day 2 | | Day 3 | | Day 4 | |
|---|---|---|---|---|---|---|---|---|
| Subjects | % correct | % error | % correct | % error | % correct | % error | % correct | % error |
| 8 | 33 | 38 | 40 | 41 | 20 | 33 | 30 | 25 |
| 9 | 48 | 14 | 43 | 15 | 63 | 19 | 45 | 33 |
| 3 | 46 | 0 | 86 | 12 | 70 | 24 | 100 | 8 |
| 4 | 30 | 8 | 20 | 20 | 10 | 0 | 13 | 0 |
| 28 | 36 | 36 | 26 | 30 | 31 | 35 | 29 | 10 |
| 29 | 14 | 60 | 27 | 20 | 21 | 42 | 25 | 20 |
| 10 | 73 | 15 | 88 | 8 | 80 | 0 | 80 | 6 |
| 12 | 58 | 15 | 60 | 14 | 70 | 3 | 55 | 4 |
| 7 | 48 | 42 | 60 | 43 | 50 | 39 | 38 | 38 |
| Total | 386 | 228 | 450 | 203 | 415 | 195 | 415 | 144 |
| Mean | 42.90 | 25.33 | 50.00 | 22.56 | 46.11 | 21.67 | 46.11 | 16.00 |

Appendix A.2. (ii)

## K.R. CONDITION

Percentage correct detections of total signals presented and percentage false responses of total responses made for the last two 5 minute sessions on four consecutive days.

| Subjects | Day 1 | | Day 2 | | Day 3 | | Day 4 | |
|---|---|---|---|---|---|---|---|---|
| | % correct | % error | % correct | % error | % correct | % error | % correct | % error |
| 27 | 69 | 46 | 38 | 61 | 33 | 59 | 38 | 57 |
| 19 | 63 | 24 | 50 | 20 | 65 | 13 | 85 | 13 |
| 26 | 75 | 56 | 48 | 71 | 70 | 64 | 50 | 60 |
| 20 | 68 | 21 | 85 | 6 | 83 | 0 | 70 | 3 |
| 21 | 45 | 14 | 68 | 10 | 73 | 12 | 68 | 7 |
| 14 | 72 | 36 | 67 | 9 | 61 | 14 | 66 | 26 |
| 23 | 55 | 27 | 80 | 35 | 70 | 28 | 93 | 26 |
| Total | 453 | 224 | 436 | 212 | 455 | 190 | 470 | 192 |
| Mean | 64.71 | 31.71 | 62.29 | 30.29 | 65.00 | 27.14 | 67.14 | 27.43 |

Appendix B.1. (i)

## 100% CUING

Individual detection scores and false response scores expressed as percentages.

| | 1 | | 2 | |
|---|---|---|---|---|
| Subject No. | Correct % | Error % | Correct % | Error % |
| 1 | 80 | 4 | 70 | 11 |
| 2 | 67 | 9 | 57 | 6 |
| 3 | 53 | 0 | 73 | 2 |
| 4 | 50 | 0 | 60 | 8 |
| 5 | 47 | 7 | 52 | 6 |
| 6 | 37 | 39 | 35 | 36 |
| 7 | 37 | 8 | 73 | 12 |
| 8 | 33 | 50 | 48 | 34 |
| 9 | 33 | 44 | 28 | 58 |
| 10 | 30 | 36 | 33 | 39 |
| 11 | 30 | 36 | 37 | 37 |
| 12 | 27 | 50 | 47 | 26 |
| 13 | 23 | 56 | 40 | 48 |
| 14 | 23 | 30 | 33 | 43 |
| 15 | 23 | 42 | 72 | 14 |
| 16 | 20 | 0 | 33 | 29 |
| 17 | 10 | 0 | 30 | 0 |
| 18 | 7 | 82 | 17 | 71 |
| 19 | 0 | 0 | 52 | 0 |
| 20 | 0 | 100 | 23 | 33 |
| Total | 630 | 593 | 913 | 513 |
| Mean | 31.5 | 29.7 | 45.7 | 25.7 |

Appendix B.1. (ii)

K.R. (NON-CONTINGENT)

| Subject No. | 1 Correct % | 1 Error % | 2 Correct % | 2 Error % |
|---|---|---|---|---|
| 1 | 53 | 6 | 68 | 13 |
| 2 | 53 | 0 | 77 | 0 |
| 3 | 53 | 33 | 60 | 44 |
| 4 | 47 | 26 | 38 | 38 |
| 5 | 47 | 18 | 70 | 14 |
| 6 | 40 | 0 | 48 | 15 |
| 7 | 33 | 58 | 38 | 68 |
| 8 | 33 | 23 | 48 | 15 |
| 9 | 33 | 38 | 25 | 71 |
| 10 | 33 | 41 | 58 | 53 |
| 11 | 30 | 25 | 37 | 48 |
| 12 | 30 | 44 | 50 | 45 |
| 13 | 27 | 58 | 40 | 40 |
| 14 | 23 | 36 | 33 | 41 |
| 15 | 23 | 42 | 55 | 31 |
| 16 | 17 | 44 | 30 | 18 |
| 17 | 10 | 50 | 27 | 59 |
| 18 | 10 | 40 | 53 | 18 |
| 19 | 3 | 83 | 17 | 71 |
| 20 | 0 | 0 | 17 | 17 |
| Total | 598 | 665 | 889 | 719 |
| Mean | 29.8 | 33.3 | 44.5 | 36.0 |

Appendix F.1. (iii)

K.R. (CONTINGENT)

| Subject No. | 1st five minute session Correct % | Error % | Last two five minute sessions Correct % | Error % |
|---|---|---|---|---|
| 1 | 90 | 39 | 85 | 33 |
| 2 | 60 | 10 | 62 | 30 |
| 3 | 57 | 0 | 67 | 15 |
| 4 | 50 | 35 | 60 | 35 |
| 5 | 47 | 26 | 40 | 39 |
| 6 | 47 | 13 | 42 | 27 |
| 7 | 43 | 28 | 53 | 22 |
| 8 | 43 | 0 | 38 | 30 |
| 9 | 43 | 13 | 32 | 17 |
| 10 | 40 | 40 | 37 | 37 |
| 11 | 30 | 25 | 52 | 39 |
| 12 | 27 | 0 | 62 | 8 |
| 13 | 27 | 0 | 28 | 35 |
| 14 | 27 | 0 | 40 | 33 |
| 15 | 23 | 0 | 43 | 28 |
| 16 | 23 | 22 | 27 | 33 |
| 17 | 23 | 46 | 50 | 27 |
| 18 | 13 | 20 | 42 | 38 |
| 19 | 7 | 0 | 45 | 13 |
| 20 | 3 | 0 | 33 | 23 |
| Total | 723 | 317 | 938 | 562 |
| Mean | 36.2 | 15.9 | 46.9 | 28.1 |

Appendix B.1. (iv)

PARTIAL FEEDBACK CUING

| Subject No. | 1 Correct % | 1 Error % | 2 Correct % | 2 Error % |
|---|---|---|---|---|
| 1 | 57 | 32 | 38 | 41 |
| 2 | 43 | 18 | 63 | 14 |
| 3 | 43 | 35 | 37 | 44 |
| 4 | 40 | 0 | 43 | 26 |
| 5 | 37 | 8 | 42 | 40 |
| 6 | 37 | 42 | 38 | 66 |
| 7 | 37 | 50 | 23 | 44 |
| 8 | 33 | 50 | 50 | 59 |
| 9 | 33 | 0 | 32 | 5 |
| 10 | 33 | 29 | 33 | 44 |
| 11 | 33 | 29 | 32 | 49 |
| 12 | 30 | 18 | 17 | 44 |
| 13 | 30 | 31 | 25 | 20 |
| 14 | 23 | 42 | 35 | 32 |
| 15 | 20 | 14 | 28 | 6 |
| 16 | 20 | 40 | 15 | 0 |
| 17 | 20 | 0 | 38 | 30 |
| 18 | 7 | 75 | 35 | 57 |
| 19 | 6 | 33 | 23 | 33 |
| 20 | 0 | 100 | 28 | 53 |
| Total | 582 | 646 | 675 | 707 |
| Mean | 29.1 | 32.3 | 33.8 | 35.4 |

Appendix B.1. (v)

## PARTIAL FEEDBACK CUING + KR (CONTINGENT)

| Subject No. | First five minute session Correct % | Error % | Last two five minute sessions. Correct % | Error % |
|---|---|---|---|---|
| 1 | 67 | 0 | 63 | 5 |
| 2 | 57 | 6 | 75 | 18 |
| 3 | 57 | 15 | 62 | 14 |
| 4 | 53 | 33 | 60 | 32 |
| 5 | 50 | 12 | 57 | 6 |
| 6 | 50 | 17 | 70 | 13 |
| 7 | 47 | 42 | 60 | 44 |
| 8 | 43 | 46 | 47 | 26 |
| 9 | 40 | 14 | 38 | 32 |
| 10 | 33 | 9 | 43 | 0 |
| 11 | 30 | 10 | 52 | 21 |
| 12 | 30 | 36 | 35 | 25 |
| 13 | 30 | 53 | 38 | 48 |
| 14 | 27 | 27 | 47 | 13 |
| 15 | 27 | 33 | 43 | 21 |
| 16 | 27 | 47 | 58 | 39 |
| 17 | 13 | 0 | 27 | 43 |
| 18 | 13 | 33 | 25 | 50 |
| 19 | 13 | 33 | 33 | 38 |
| 20 | 3 | 50 | 22 | 48 |
| Total | 710 | 516 | 955 | 536 |
| Mean | 35.5 | 25.8 | 47.8 | 26.8 |

Appendix B.2. (i)

CUING (100%)

| Subject No. | Pre-training | Post-training | Difference |
|---|---|---|---|
| 1 | .45001 | .33315 | - .11686 |
| 2 | .31994 | .27631 | - .04363 |
| 3 | .29042 | .41136 | + .12094 |
| 4 | .26900 | .28569 | + .01669 |
| 5 | .21401 | 24446 | + .03045 |
| 6 | .08311 | .08399 | + .00088 |
| 7 | .15694 | .34776 | + .19082 |
| 8 | .05180 | .13177 | + .07997 |
| 9 | .06302 | .03000 | - .03302 |
| 10 | .07134 | .07319 | + .00185 |
| 11 | .07134 | .08702 | + .01568 |
| 12 | .03977 | .14896 | + .10919 |
| 13 | .05281 | .07032 | + .01751 |
| 14 | .06168 | .06621 | + .00453 |
| 15 | .04552 | .32588 | + .28036 |
| 16 | .09791 | .09517 | - .00274 |
| 17 | .04764 | .15119 | + .10355 |
| 18 | .00012 | .00405 | + .00393 |
| 19 | 0 | .27964 | + .27964 |
| 20 | .00651 | .05701 | + .05050 |
| Total | 2.39289 | 3.50313 | |
| Mean | .11964 | .17516 | |

Appendix B.2. (ii)

K.R. (NON-CONTINGENT)

| Subject No. | Pre-training | Post-training | Difference |
|---|---|---|---|
| 1 | .25491 | .31120 | + .05629 |
| 2 | .29042 | .46137 | + .17095 |
| 3 | .15227 | .13786 | - .01441 |
| 4 | .14896 | .09016 | - .05880 |
| 5 | .17560 | .31381 | + .13821 |
| 6 | .20799 | .19318 | - .01481 |
| 7 | .03489 | .01882 | - .01607 |
| 8 | 10666 | .19318 | + .08652 |
| 9 | .07700 | .01091 | - .06609 |
| 10 | .06960 | .09777 | + .02817 |
| 11 | .09099 | .06357 | - .02742 |
| 12 | .05689 | .10166 | + .04477 |
| 13 | .02729 | .08963 | + .06234 |
| 14 | .05281 | .06960 | + .01679 |
| 15 | .04553 | .16592 | + .12039 |
| 16 | .0[illegible]77 | .10415 | + .07538 |
| 17 | .01357 | .02559 | + .01202 |
| 18 | .01921 | .20593 | + .18672 |
| 19 | .00022 | .00405 | + .00383 |
| 20 | 0 | .05667 | + .05667 |
| Total | 1.85358 | 2.71503 | |
| Mean | .09268 | .13575 | |

Appendix B.2. (iii).

K.R. (CONTINGENT)

| Subject No. | Pre-training | Post-training | Difference |
|---|---|---|---|
| 1 | .30832 | .30890 | + .00058 |
| 2 | .27449 | .19797 | - .07652 |
| 3 | .31246 | .29046 | - .02200 |
| 4 | .13543 | .17374 | + .03831 |
| 5 | .14896 | .09342 | - .05554 |
| 6 | .19259 | .12935 | - .06324 |
| 7 | .13203 | .19152 | + .05949 |
| 8 | .22782 | .10794 | - .11988 |
| 9 | .1737[illegible] | .11235 | - .06139 |
| 10 | .08963 | .08702 | - .00261 |
| 11 | .09099 | .12681 | + .03582 |
| 12 | .13307 | .29688 | + .16381 |
| 13 | .13307 | .06869 | - .06438 |
| 14 | .13307 | .10606 | - .02701 |
| 15 | .11531 | .13203 | + .01672 |
| 16 | .07286 | .06618 | - .00668 |
| 17 | .03937 | .15512 | + .11575 |
| 18 | .04192 | .10071 | + .05879 |
| 19 | .03149 | .18309 | + .15160 |
| 20 | .01561 | .10666 | + .09105 |
| Total | 2.80223 | 3.03490 | |
| Mean | .14011 | .15175 | |

Appendix B.2. (iv)

## PARTIAL FEEDBACK CUING

| Subject No. | Pre-training | Post-training | Difference |
|---|---|---|---|
| 1 | .16991 | .08268 | - .08723 |
| 2 | .15742 | .27689 | + .11947 |
| 3 | .11245 | .07260 | - .03985 |
| 4 | .20799 | .13771 | - .07028 |
| 5 | .15694 | .09305 | - .06387 |
| 6 | .07592 | .02311 | - .05281 |
| 7 | .05821 | .04232 | - .01589 |
| 8 | .05180 | .05794 | + .00614 |
| 9 | .16970 | .14206 | - .02764 |
| 10 | .09517 | .06302 | - .03215 |
| 11 | .09517 | .05128 | - .04389 |
| 12 | .10415 | .02877 | - .0[illegible]8 |
| 13 | .08031 | .07423 | - .006[illegible] |
| 14 | .04552 | .09276 | + .04724 |
| 15 | .07206 | .12430 | + .05224 |
| 16 | .04030 | .07243 | + .03213 |
| 17 | .09791 | .10794 | + .01003 |
| 18 | .00060 | .05248 | + .05188 |
| 19 | .01515 | .05701 | + .04136 |
| 20 | .00216 | .03798 | + .03582 |
| **Total** | 1.80884 | 1.69056 | |
| **Mean** | .09044 | .08453 | |

Appendix B.2. (v)

PARTIAL FEEDBACK CUING & KR (CONTINGENT)

| Subject No. | 1st test session | Last two test sessions | Difference |
|---|---|---|---|
| 1 | .38285 | .32127 | - .06158 |
| 2 | .27631 | .31745 | + .04114 |
| 3 | .23416 | .26590 | + .03174 |
| 4 | .15293 | .18332 | + .03039 |
| 5 | .21206 | .27631 | + .06425 |
| 6 | .19443 | .32312 | + .12869 |
| 7 | .10390 | .13786 | + .03396 |
| 8 | .08328 | .14896 | + .06568 |
| 9 | .15548 | .10308 | - .05240 |
| 10 | .13896 | .22782 | + .08886 |
| 11 | .12148 | .18893 | + .06745 |
| 12 | .07134 | .10853 | + .03719 |
| 13 | .04092 | .06691 | + .02599 |
| 14 | .07599 | .19259 | + .11660 |
| 15 | .06618 | .15033 | + .08415 |
| 16 | .04503 | .15189 | + .10686 |
| 17 | .06409 | .05106 | - .01303 |
| 18 | .03116 | .03691 | + .00575 |
| 19 | .03116 | .07700 | + .04584 |
| 20 | .00437 | .03389 | + .02952 |
| Total | 2.48608 | 3.36313 | |
| Mean | .12430 | .16816 | |